Condition surveys and renovation measures of buildings – thermal performance of building envelopes

T. Kauppinen

VTT IN BRIEF

Units:

VTT Electronics
VTT Information Technology
VTT Industrial Systems
VTT Processes
VTT Biotechnology
VTT Building and Transport

VTT Information Service
VTT Corporate Management and Services

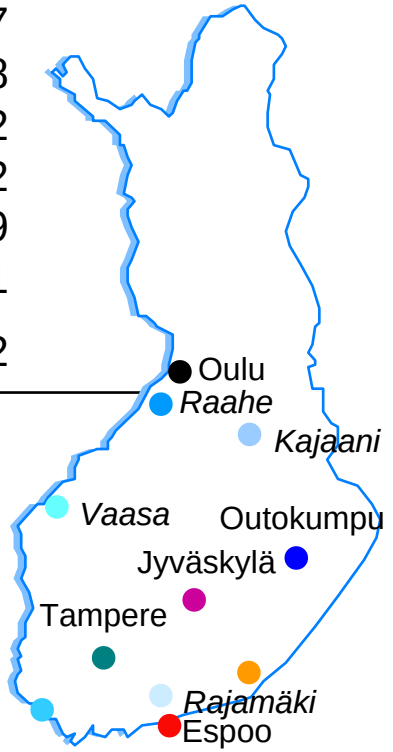
Staff: 3 012

Turnover: 214 M€

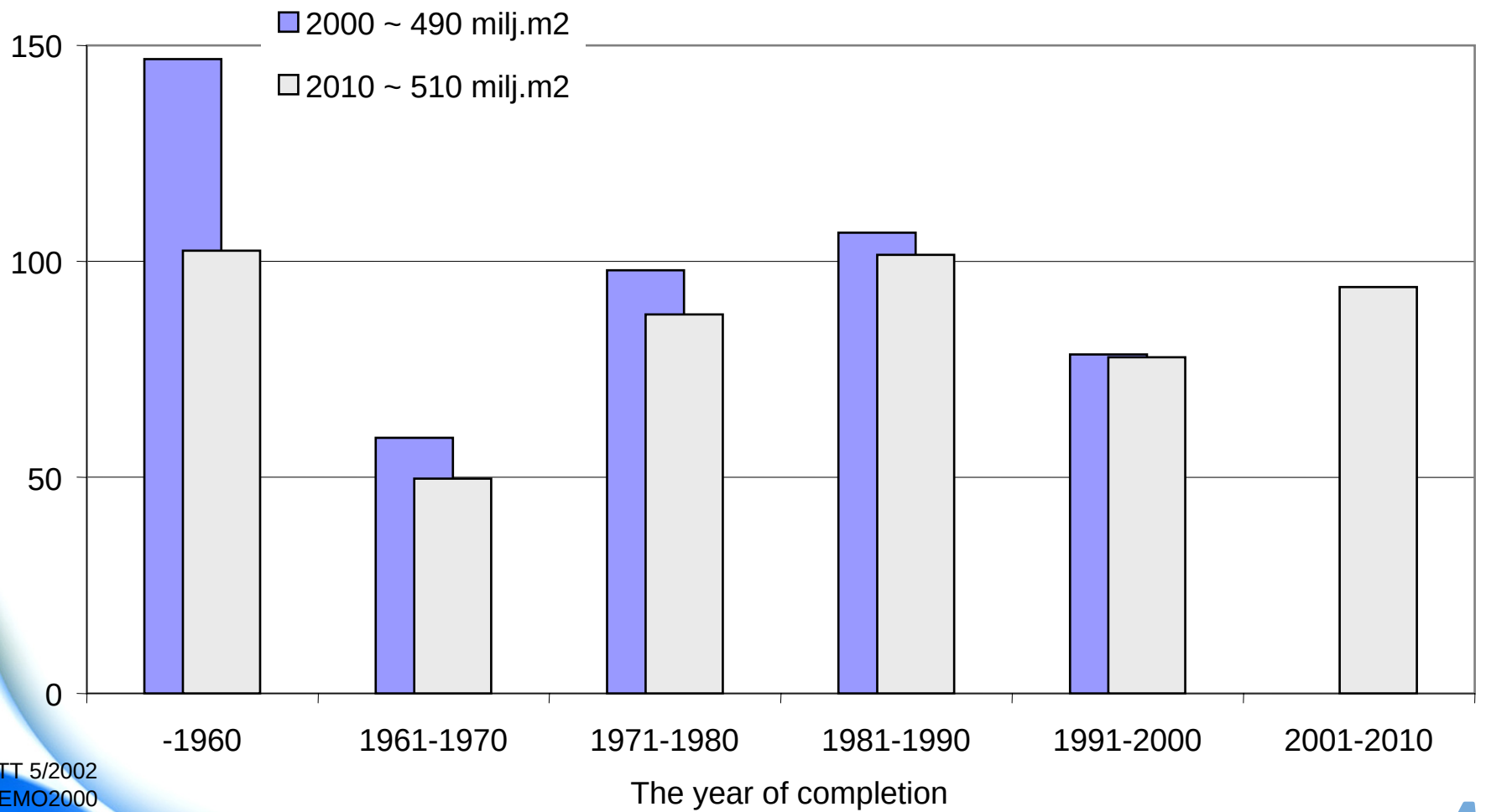
- Basic govern. funding to R&D on VTT's own initiative 34 M€
- Jointly funded projects 92 M€
- Commercial activities 88 M€

Staff breakdown by **location:**

Oulu	323
Outokumpu	37
Jyväskylä	128
Tampere	332
Lappeenranta	12
Espoo	2 159
Others	21
Total	3 012

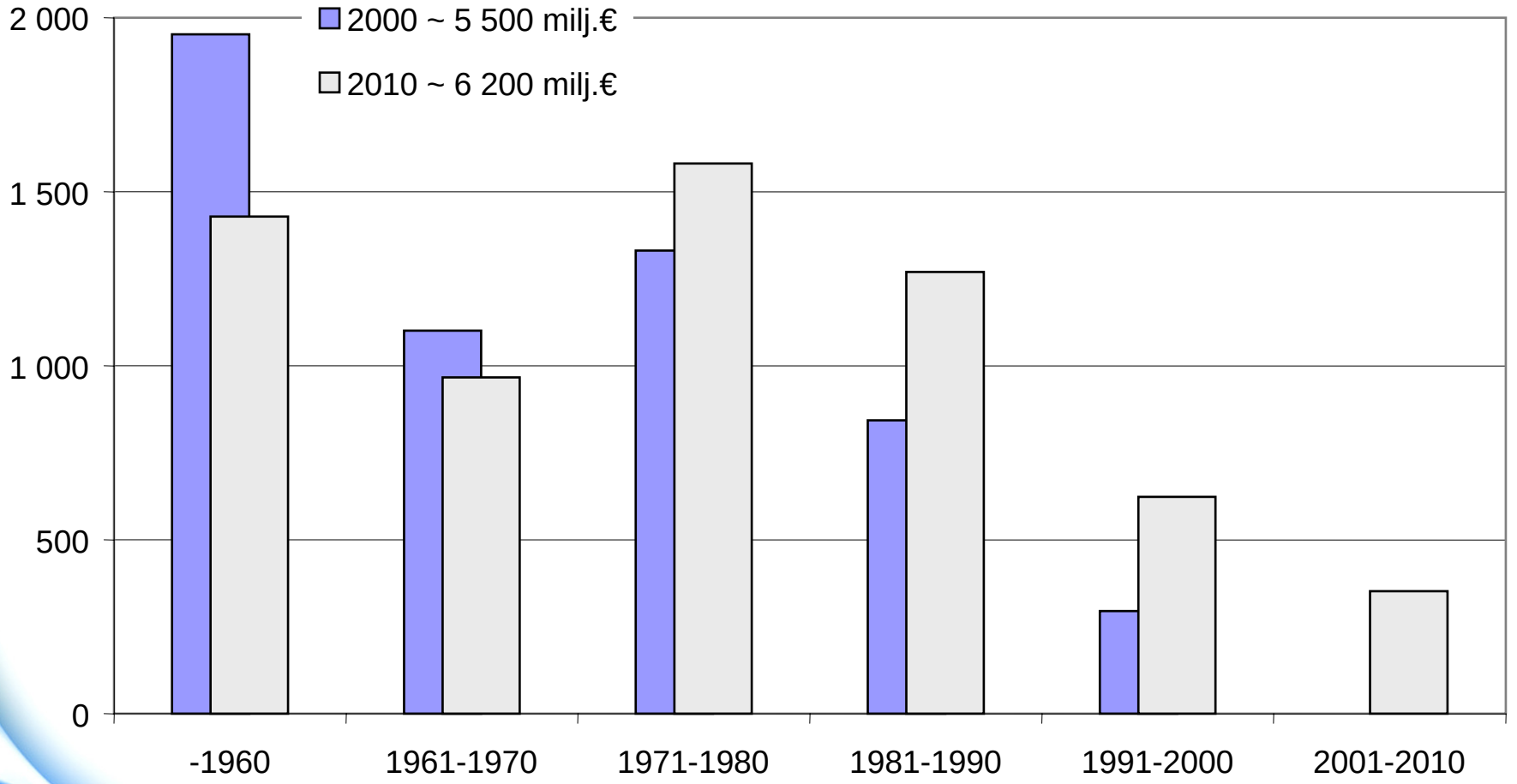


The building stock in the years 2000 and 2010 (Finland)

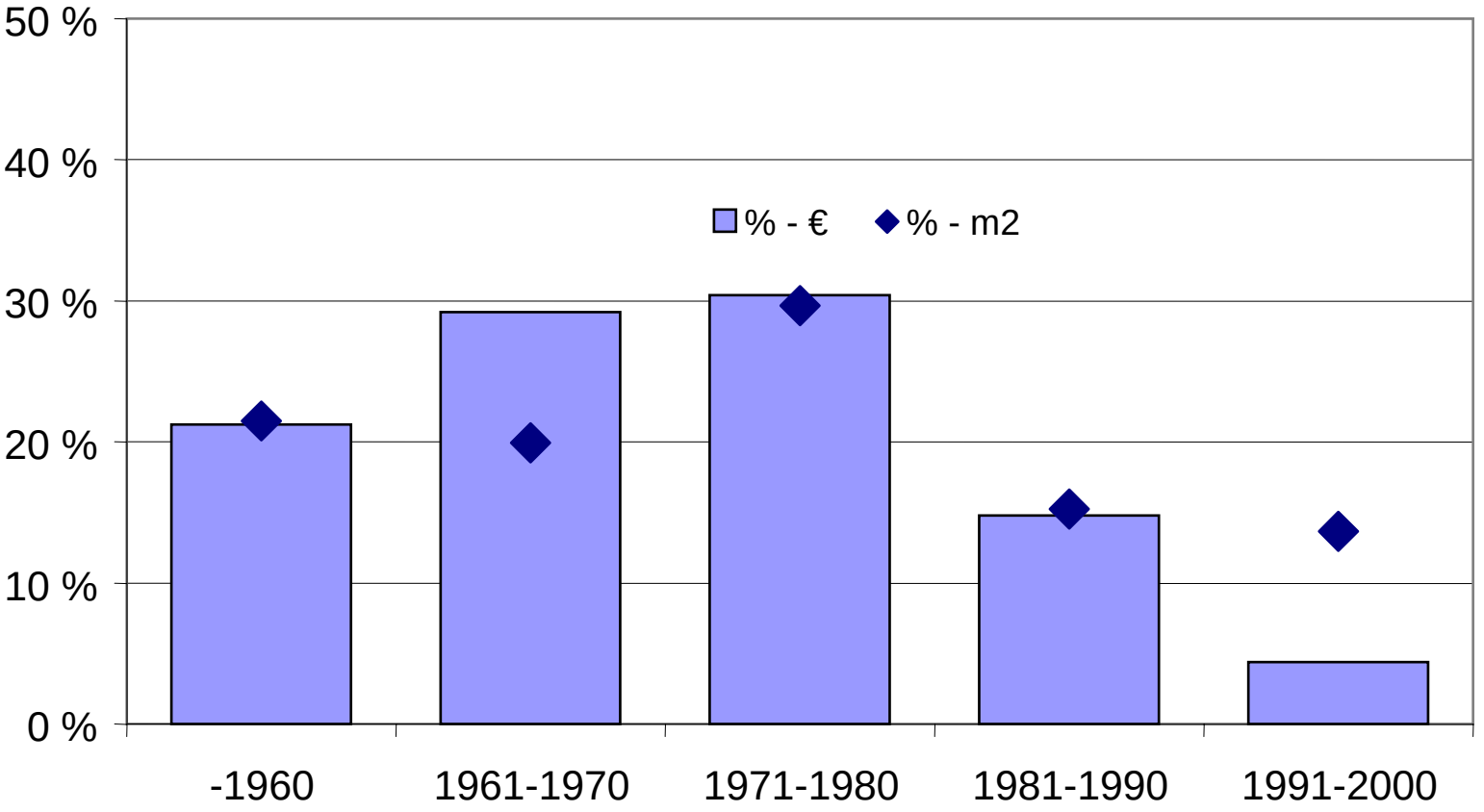


VTT 5/2002
REMO2000

Renovation of buildings in the years 2000 and 2010



Renovation of apartment houses 1 410 milj.€, according to the age



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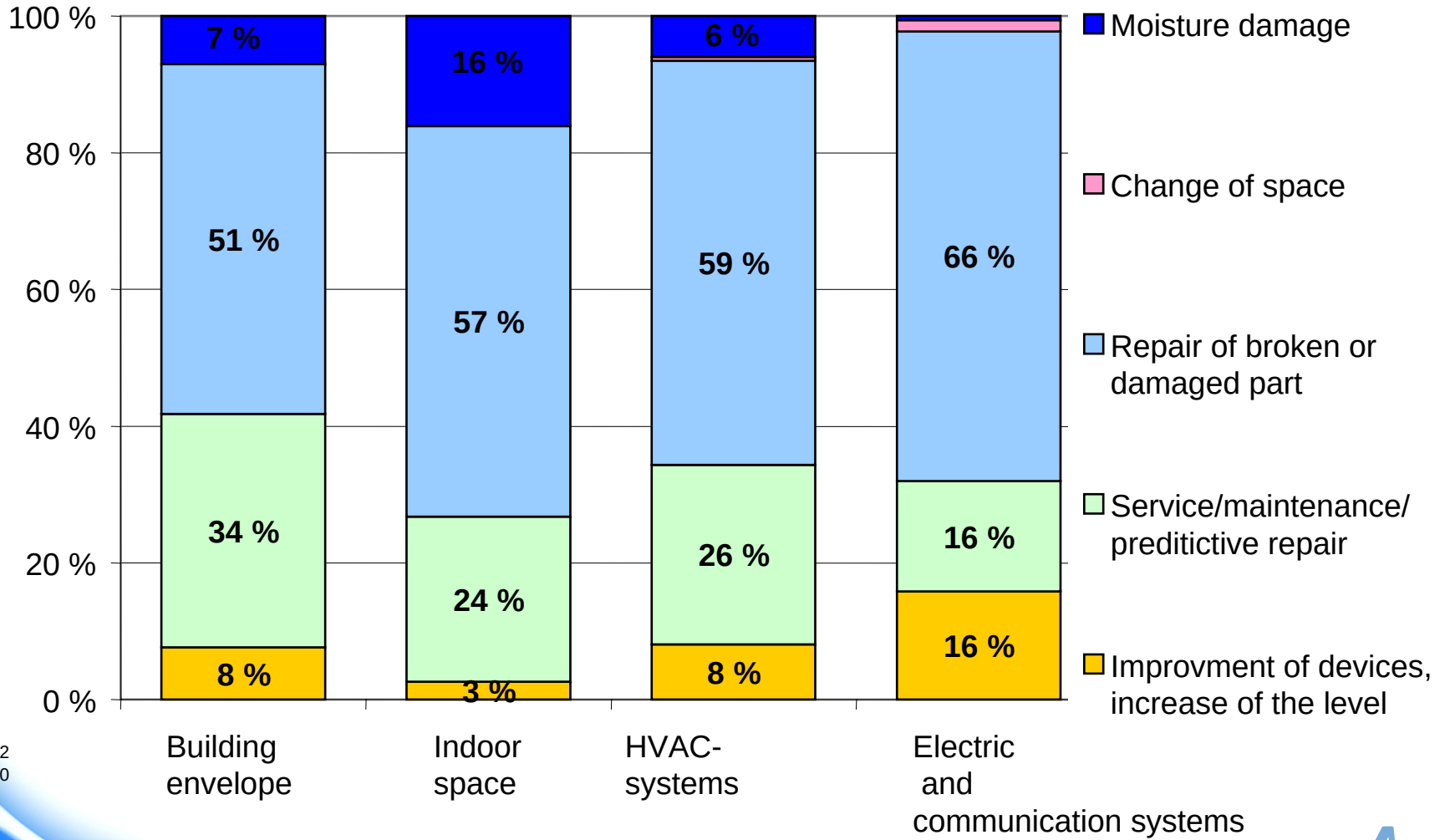
The base for renovation of apartment houses



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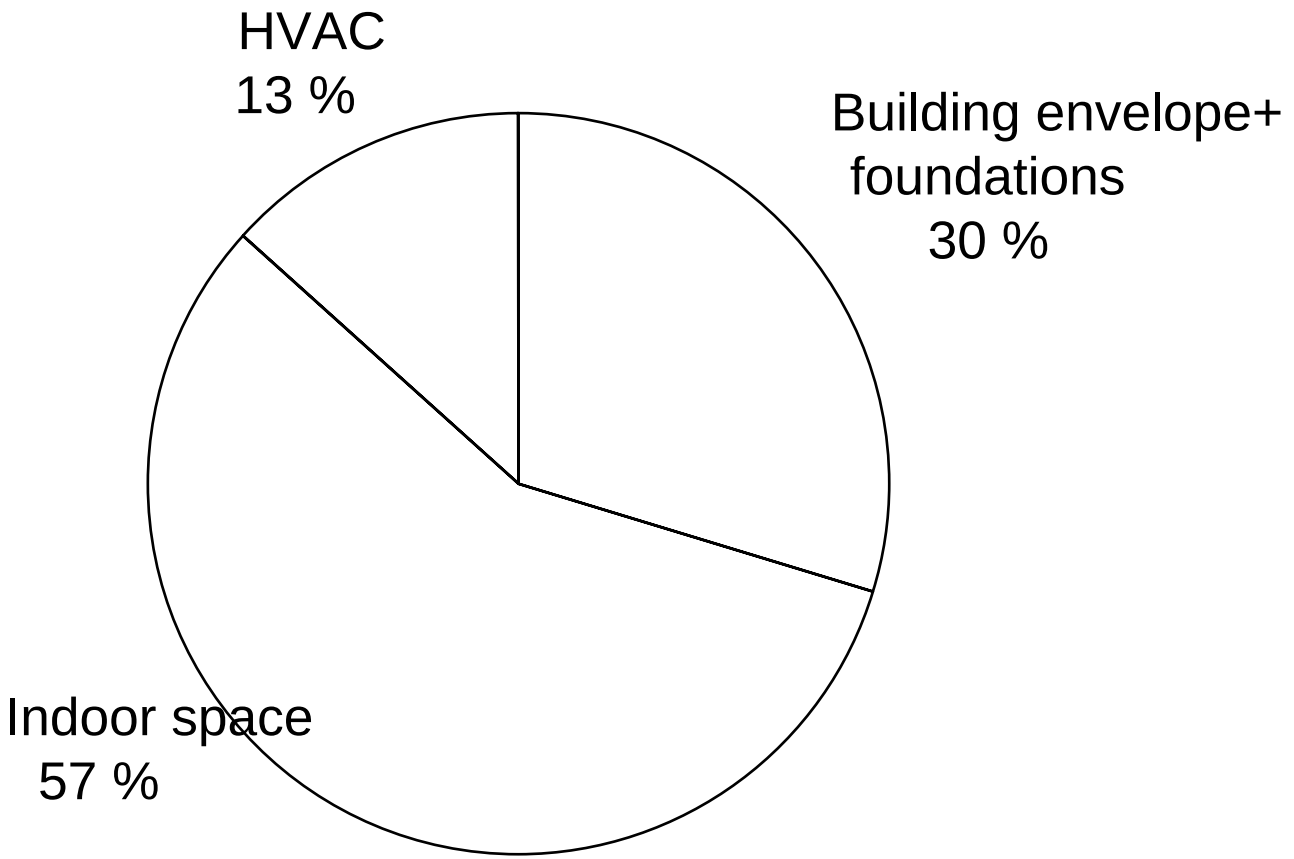
Renovation of apartment houses, 1 410 mio € total in the year 2000



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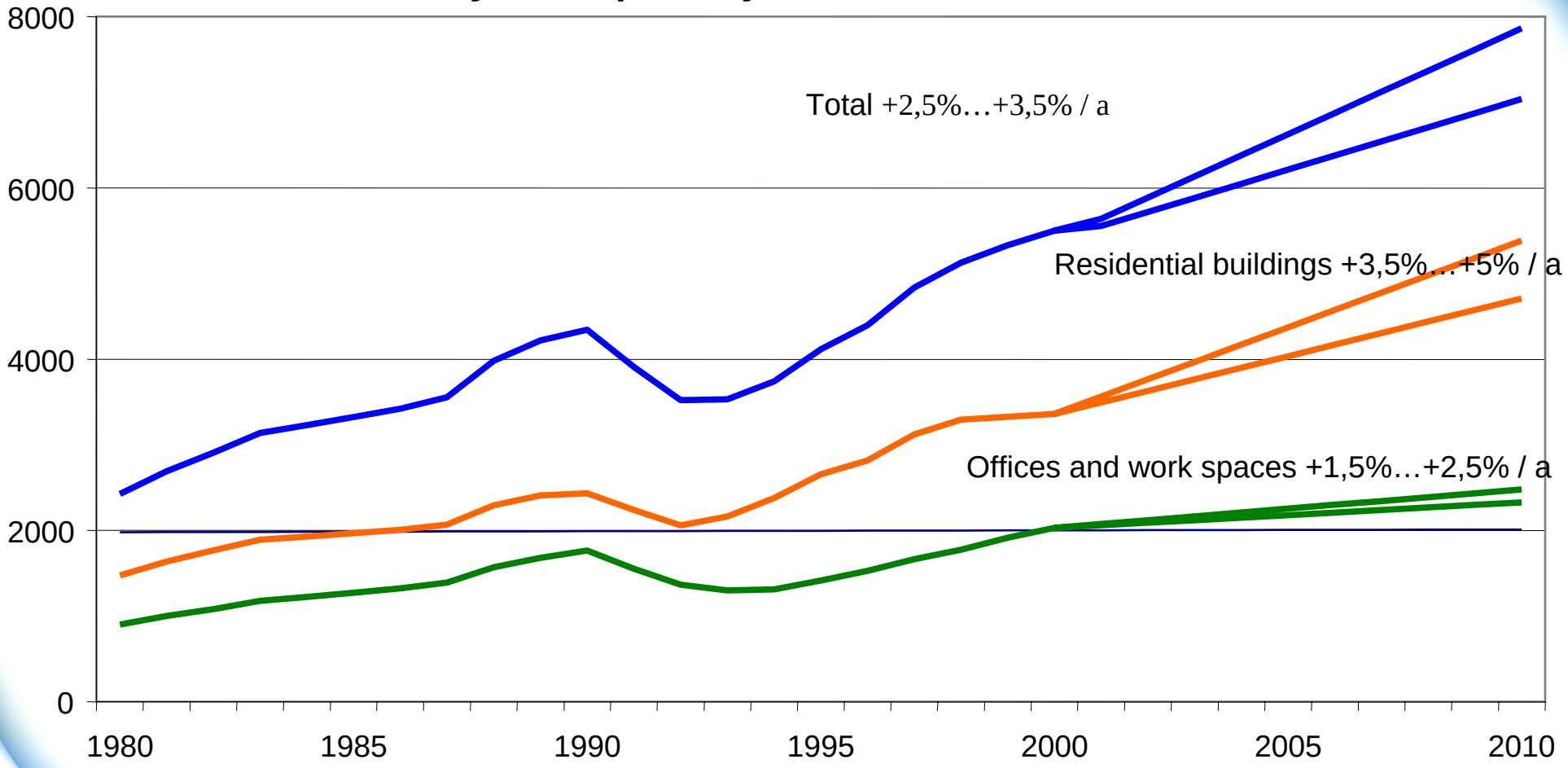
Renovation to 2010

Mio €, by fixed prices year 2000



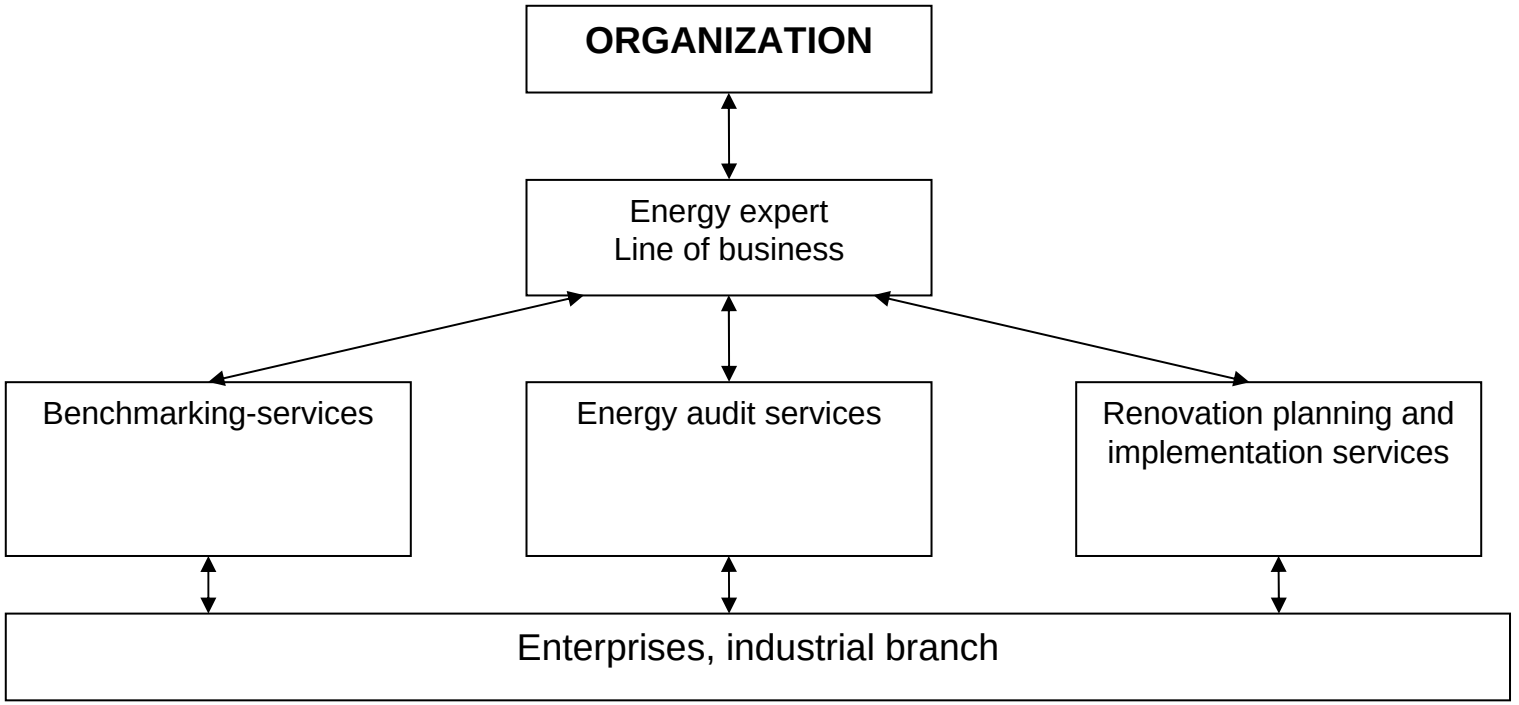
VTT 5/2002
REMO2000

Large-scale monitoring of the building stock

- Continuous monitoring and data logging (larger areas)
- References to the other countries (e.g. Finland) and equal climate zones
- Based on the collected data – energy saving project
- Internet-base platform
- More detailed instrumentation needed (or regrouping)
  - E.g. Distribution of electricity
- Data collection and transmission – building automation system and/or additional systems
- The goal: Optimization of LCC, improvement of FM

Monitoring – benchmarking - decision-making

From monitoring to actions –
rationalization of energy use



Monitoring – benchmarking - decision-making

- The next slides show an example of an interactive tool
- Printing houses, 3 different types of companies
- The blue column represents ”our” company – we can compare various things and factors with others and with our own history monthly and yearly

Benchmarking (Pro Management Intelligence /PROMAIN), www.promain.fi. 25 Printing Houses

Vuosiraportit - Microsoft Internet Explorer

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- Tietokannan hallinta
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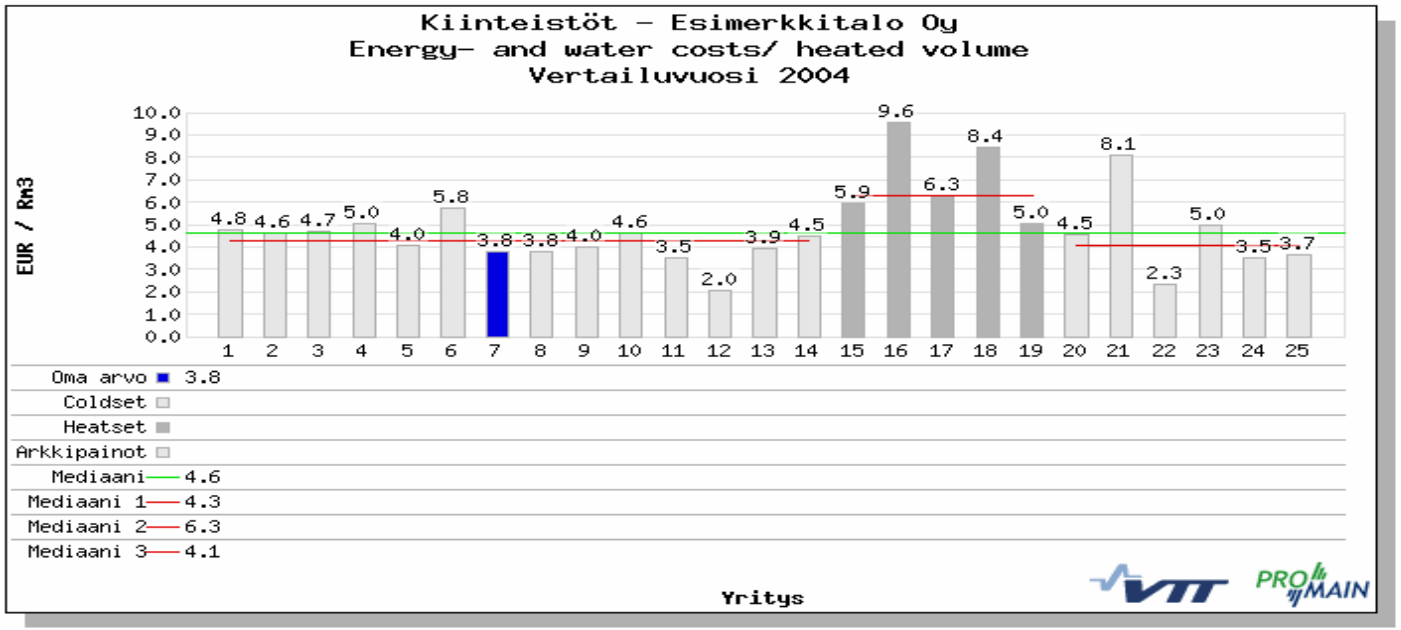
- Kirjaudu ulos

Vuosiraportit

Vuosiraportit » Kiinteistöt - Esimerkkitalo Oy » Energy- and water costs/ heated volume

Tulostettava versio



Tarkastelujakso		Omat muistiinpanot	
Vuosi	2004	Vuosi	2005

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Benchmarking

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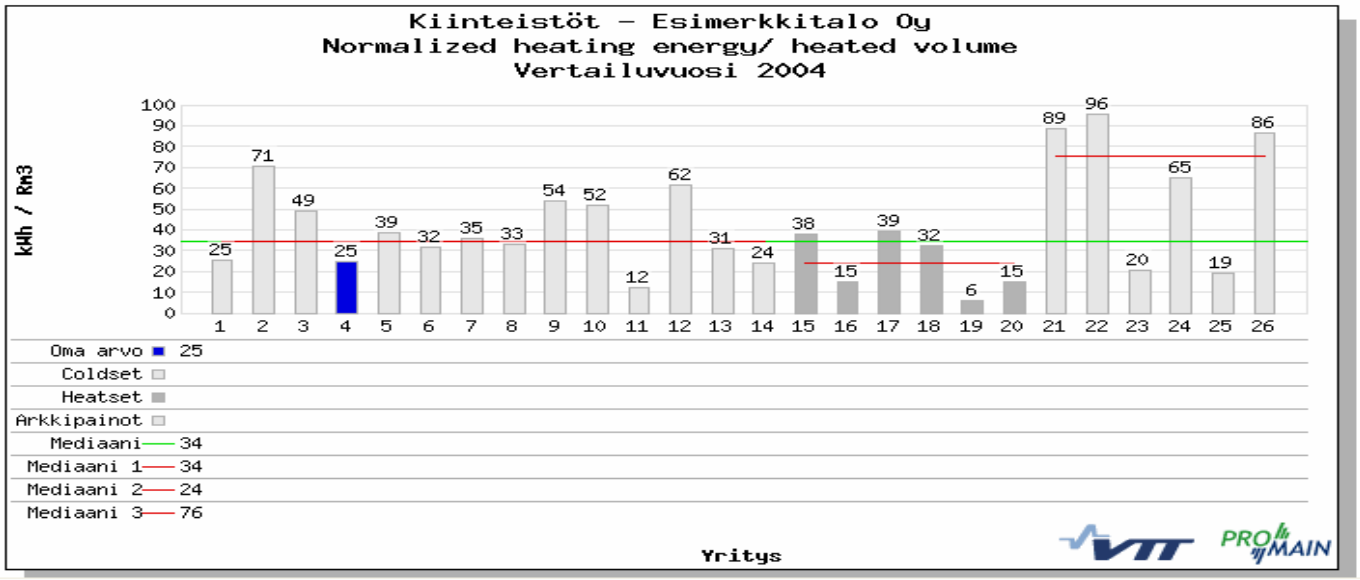
Vuosiraportit

Vuosiraportit » Kiinteistöt - Esimerkkitalo Oy » Normalized heating energy/ heated volume

Tulostettava versio



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Benchmarking

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Vuosiraportit

Vuosiraportit » Kiinteistöt - Esimerkkitalo Oy » Normalized heating energy/ heated volume (trend)

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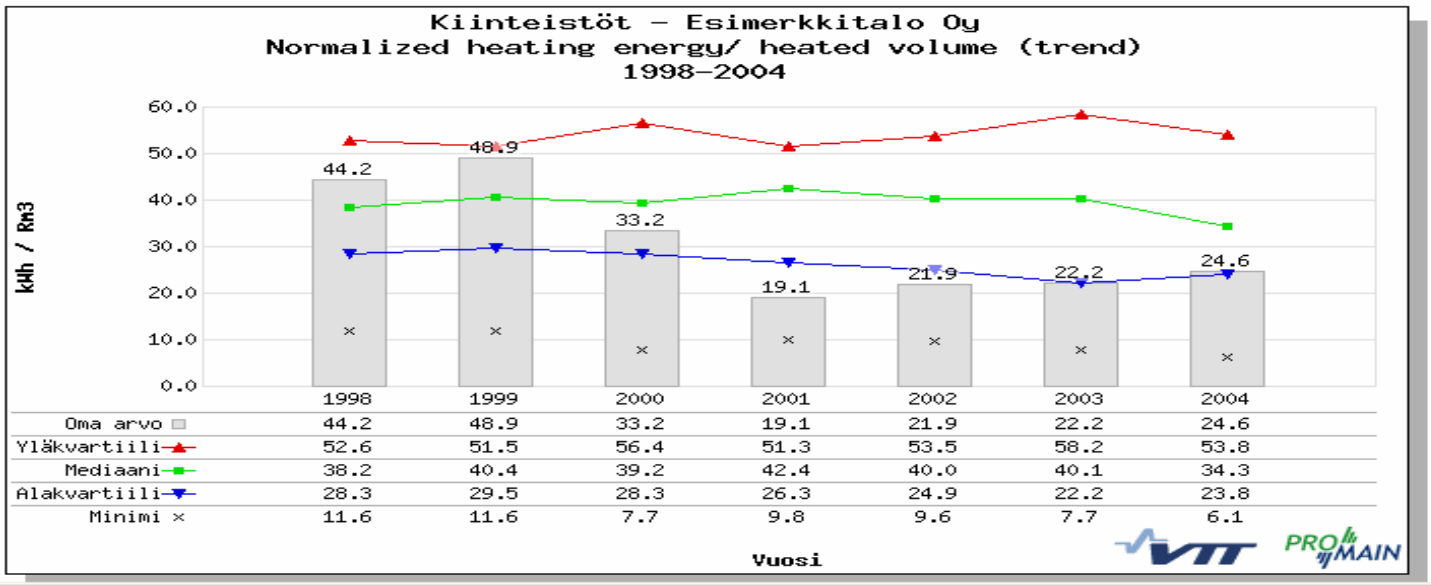

	1998	1999	2000	2001	2002	2003	2004
Oma arvo	44.2	48.9	33.2	19.1	21.9	22.2	24.6
Yläkvartiili	52.6	51.5	56.4	51.3	53.5	58.2	53.8
Mediaani	38.2	40.4	39.2	42.4	40.0	40.1	34.3
Alakvartiili	28.3	29.5	28.3	26.3	24.9	22.2	23.8
Minimi ×	11.6	11.6	7.7	9.8	9.6	7.7	6.1

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Benchmarking

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Vuosiraportit

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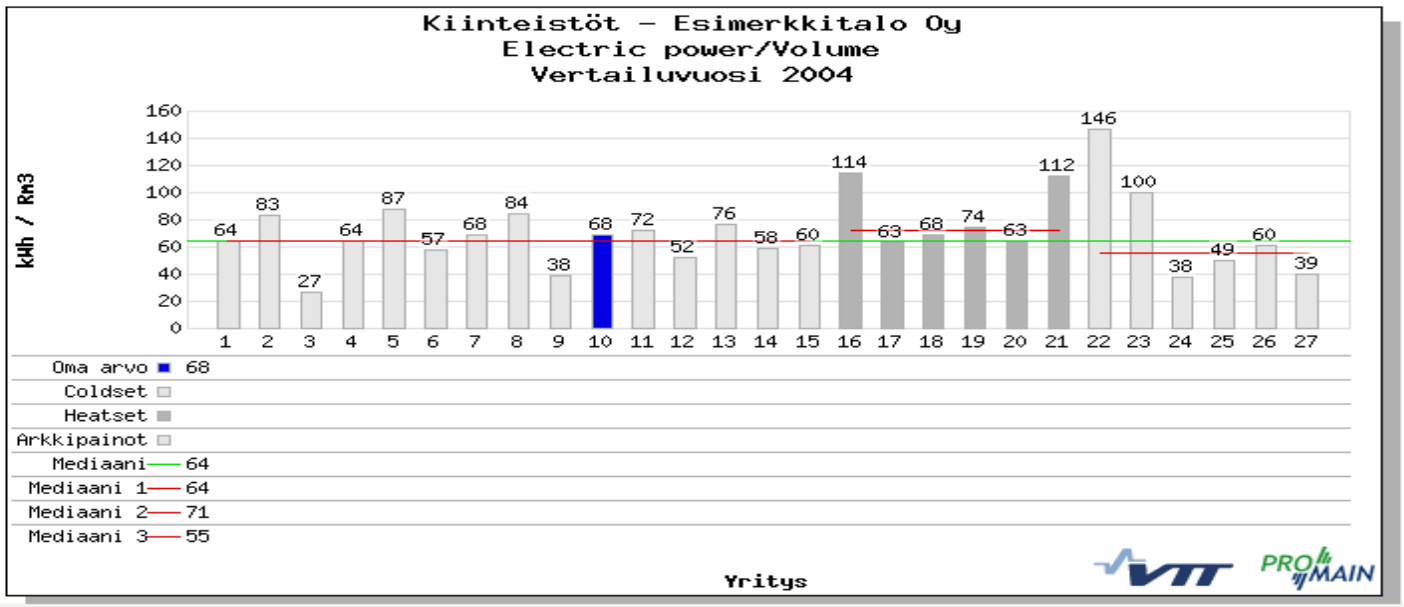

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Benchmarking, energy-, -water and cleaning costs / heated volume

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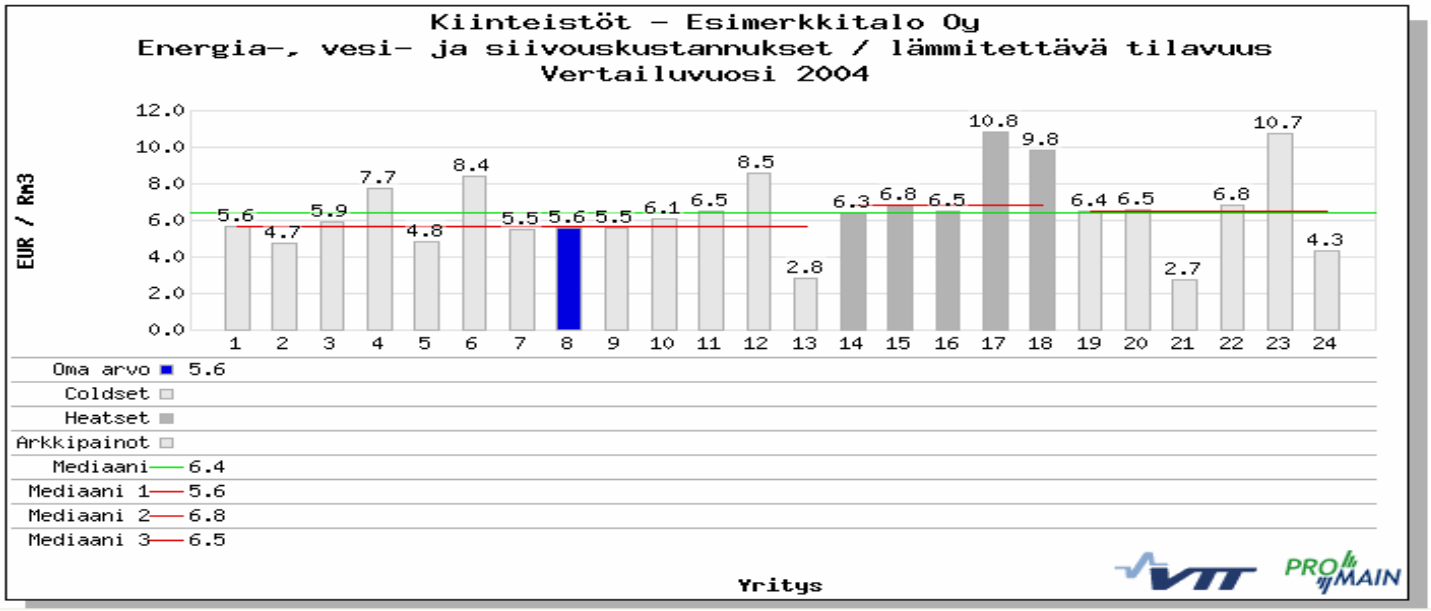
Vuosiraportit

Vuosiraportit » Kiinteistöt - Esimerkkitalo Oy » Energia-, vesi- ja siivouskustannukset / lämmitettävä tilavuus

Tulostettava versio



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Benchmarking, energy-, -water and cleaning costs / total turnover

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Vuosiraportit

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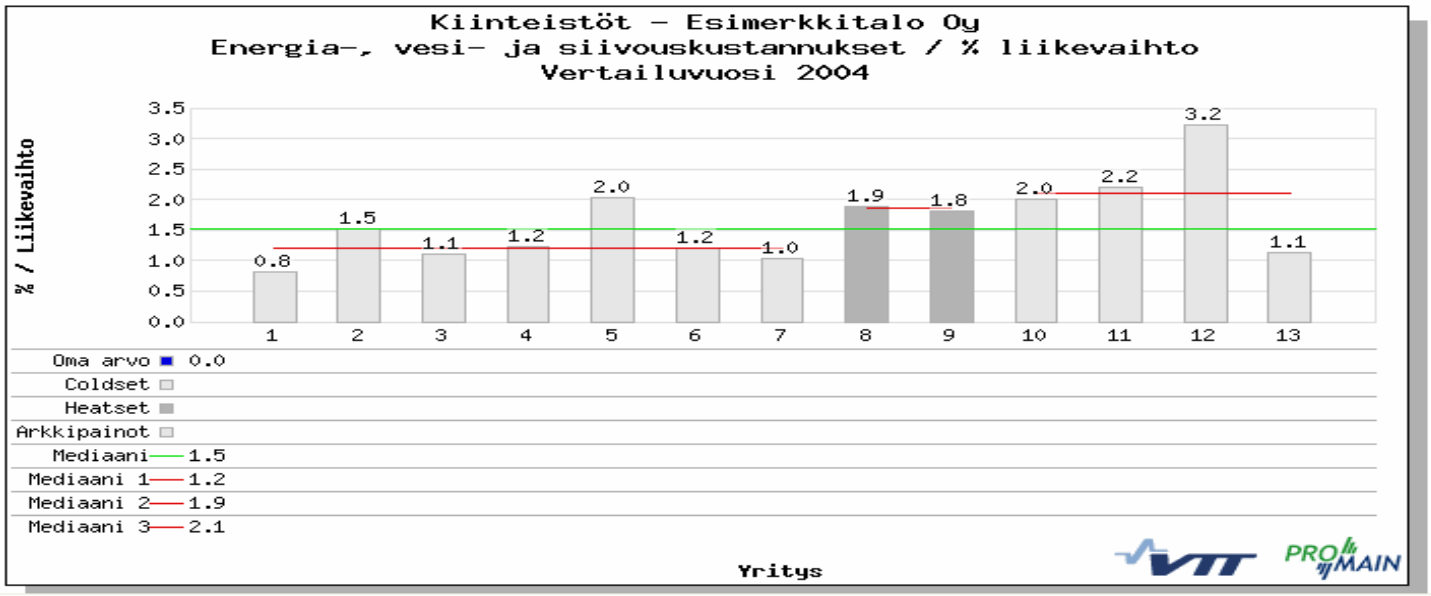

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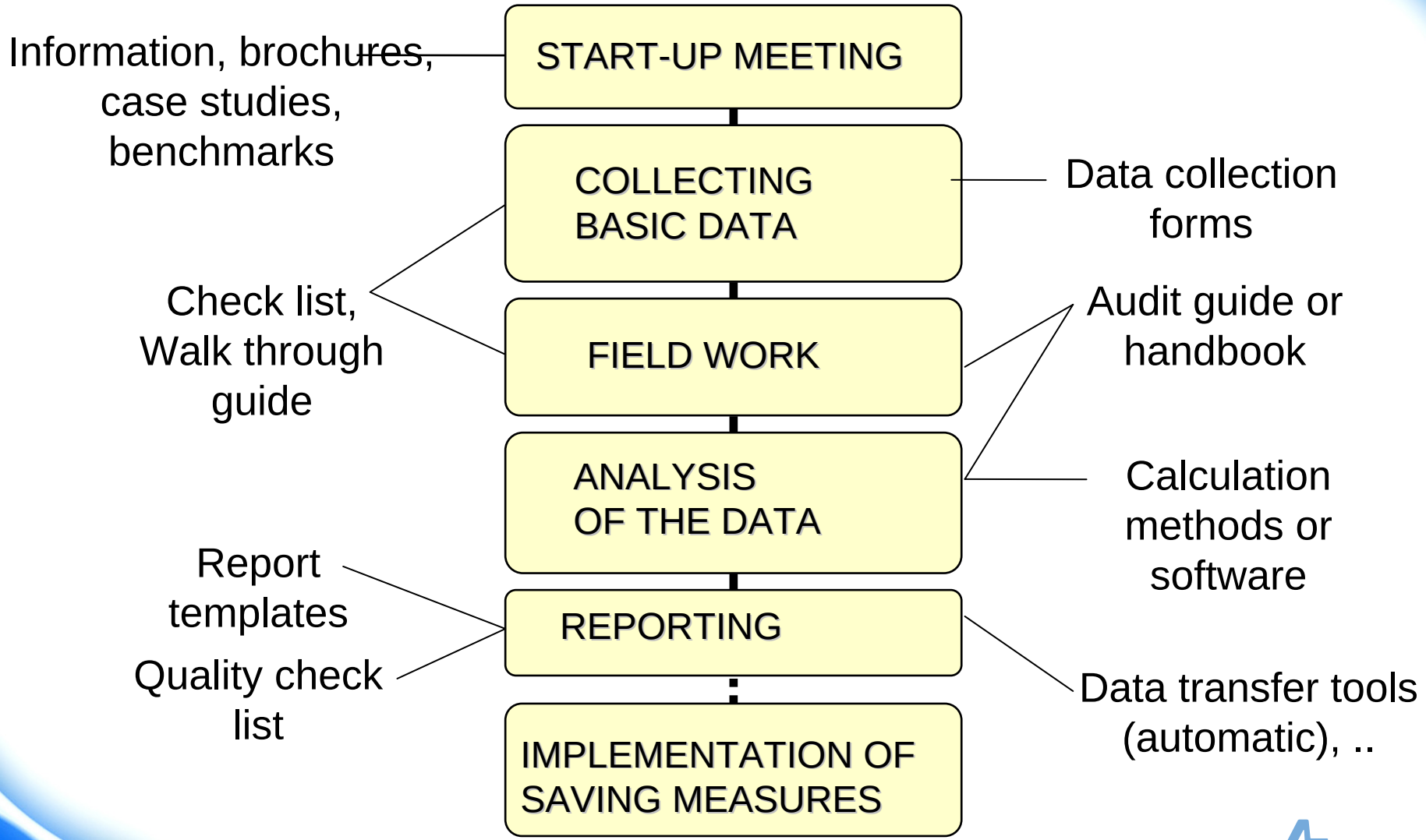
Motiva

Energiankäytön uusi suunta

Energy Auditors' Tools

Different tools for auditors



Auditor's tools in Finland

- **Guidelines (updated yearly by Motiva and MTI)**
- **Auditor's Handbook,**
  - 400 pages on audit procedure and technical issues
  - updated
  - available on web-site
- **Best Practice Reports**
- **Check-lists and Data Sheets for field-work**
- **Calculation tool Motiwatti 2.0**
- **Marketing material**
  - brochures
  - case studies

Motiwatti 2.0 software

- Developed specifically for auditors
- Shareware available to authorised auditors
- First version (Excel) developed in 1993
- Cost of development of 2.0- version: 100 000 €
- The building is modelled ⇒ auditor can start simulation on saving measures
- Includes standard reporting tables
- Will calculate CO_2 reductions
- Net effect of overlapping measures is calculated automatically
- Finnish and Swedish user interface and weather data

Motiwatti 2.0 calculation tool

1 Basic data for the target

2 Calculation of the present consumption based on the basic data

3 Modelling of the present consumption
Room spaces and losses by conduction
Energy consumption of ventilation systems
Consumption distributon of water
Consumption distributon of electricity

4 Creating of rules
Comparison between ”before” and ”after”
Evaluation of the gross effect of savings

4 Tariff comparisons

5 Creation of the order of actions and investments
Evaluation of the net effect of savings

Large-scale monitoring (Educational buildings audited)

- **BIGGEST SAVINGS PAYBACK PERIOD**

- **Heat recovery from exhaust air 3,3 years**
- **Operating time of ventilation 0,3 years**
- **Lighting 2,4 years**

- **THE MOST RECOMMENDED RETROFITTING OPERATIONS REPAYMENT PERIOD**

- **Lighting 2,4 years**
- **Restrain of flow of water fittings 1,4 years**
- **Operating time of ventilation 0,3 years**
- **Adjustment of heating network 4,9 years**

Large-scale monitoring
Educational buildings

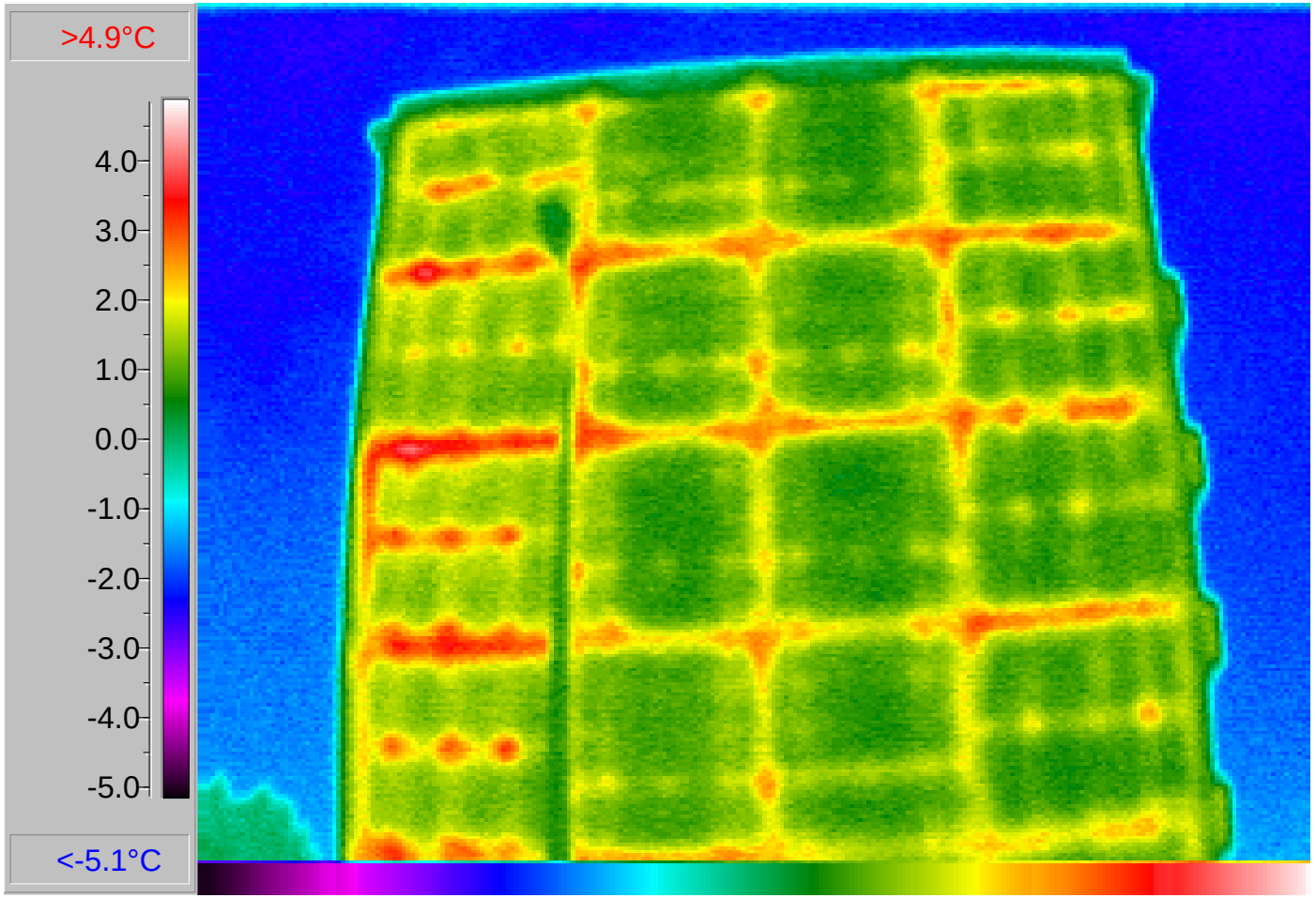
• SHORTEST REPAYMENT (PAYBACK) PERIOD	TIME
• Operating time of ventilation	0,3 year
• Readjustment of the voltage level and tariffs and the compensation of the idle power	0,6 year
• the readjustment of the contracted district heating supply capacity	0,7 year
• Adjustment of heating of ventilation equipment	1 year
• Restrain of flow of water fittings	1,4 years

Condition survey and performance studies
Condition survey before renovation – commissioning
Based on the results of benchmarking

Benchmarking (if needed, comparison to the surrounding/same type of buildings, if information available)

- Monitoring of the thermal performance of exterior walls
  - outdoor and indoor thermography
  - blower-door tests (air tightness of the apartments and work spaces)
  - heat-flux measurements (if necessary)
  - indoor surface tempererature measurements (single/continued)
  - quality of the concrete and reinforcement
  - checking of the windows and panel seams
  - thermal comfort (draft)

Condition survey and performance studies
The facade of multistorey house, heat leaks



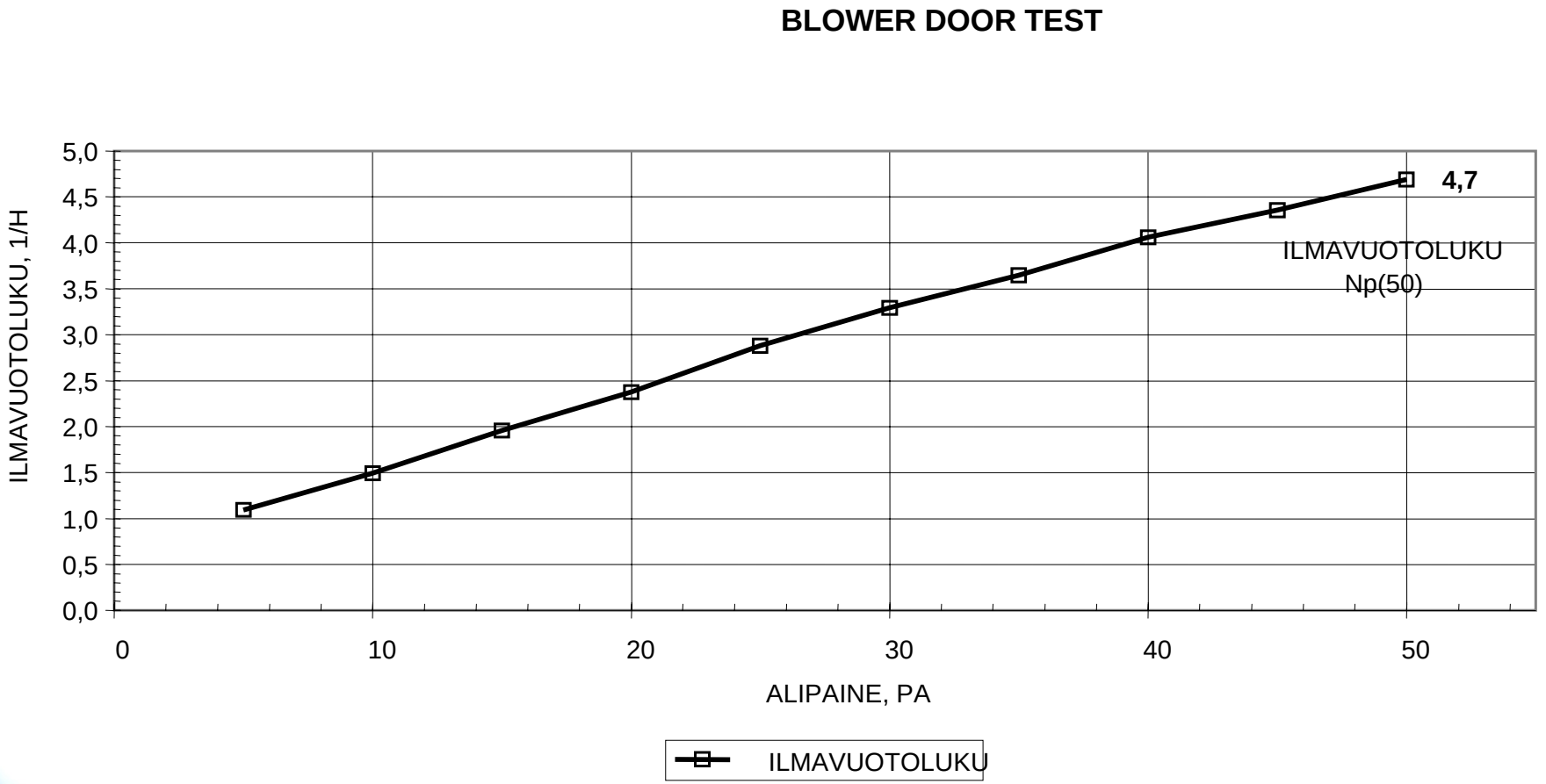
Condition survey and performance studies
Condition survey before renovation - commissioning

- Condition survey of the ventilation system
  - rate of air exchange
  - air flows
  - pressure drops and indoor conditions
- Monitoring of the heating system
  - indoor temperature measurements (single/continuous)
  - radiator temperature measurements and operating room temperature measurements
  - flow measurements (by clamp-on ultrasonic meter)
  - the condition of the plumbing and pipelines (e.g. x-ray testing and ultrasonic tests of the wall thickness and corrosion)
- Modelling studies to determine energy saving potential of different renovation options

Air tigthtness

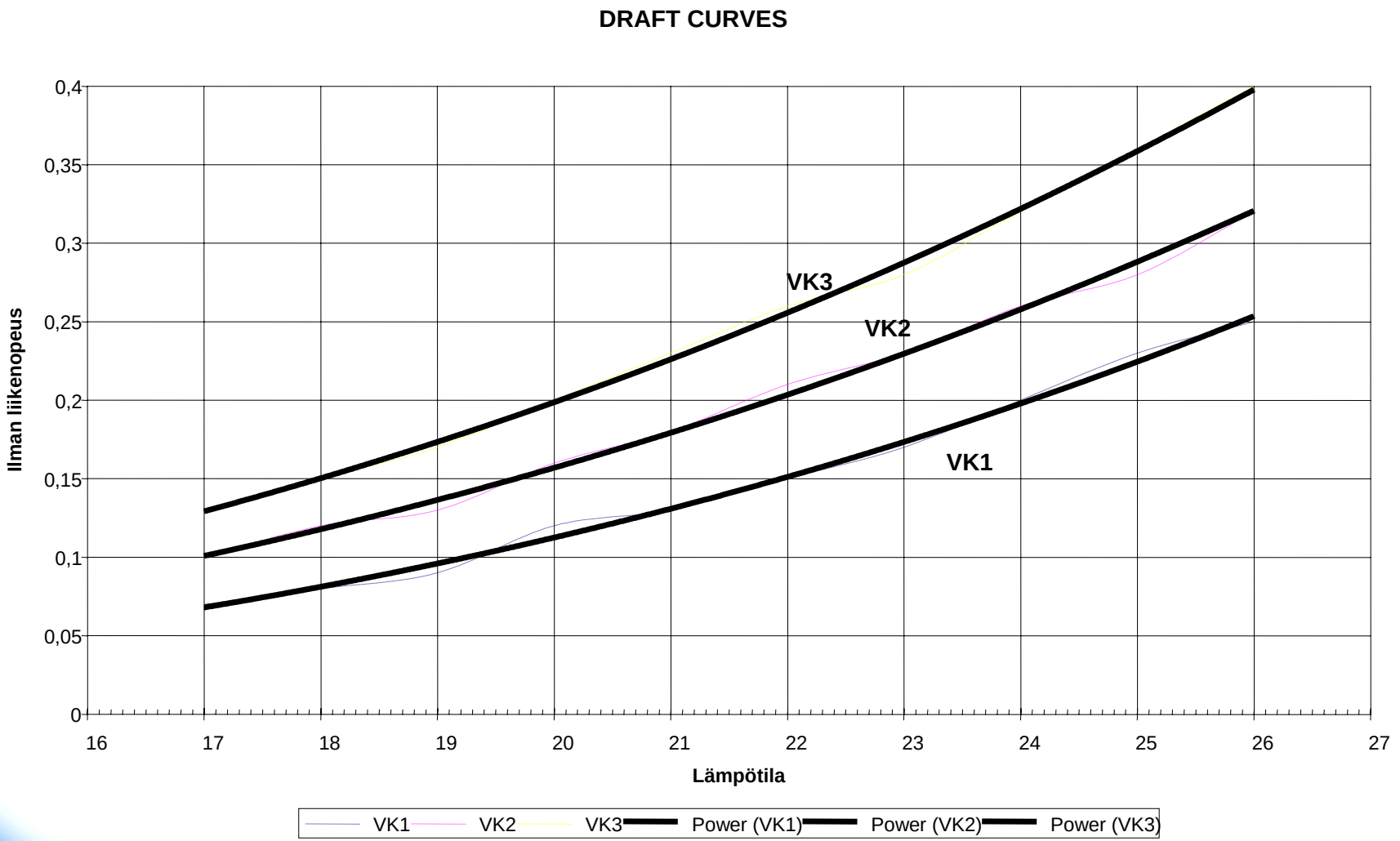
Air tightness

Leak curve



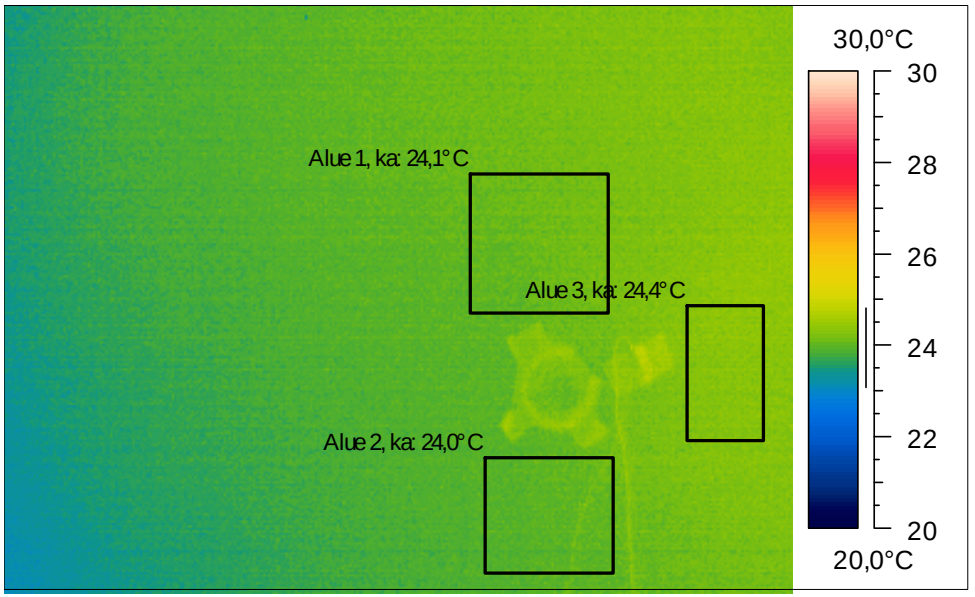
Thermal comfort

Draft curves



Measurements

Heat flux measurements



Condition survey and performance studies
Condition survey after renovation - commissioning

- Monitoring of the thermal performance of exterior walls
- Condition survey of the ventilation system
- Monitoring of the heating system
- Monitoring of the energy consumption/comparison to the estimated consumption

Condition survey and performance studies

- The costs depends on the extent and measures which must be done
- From walk-through survey to full scale study:
- Co-operation with the local organizations can decrease the costs
- Possibility for the exchange of information/experiences/training
- Possibility to create in co-operation with local organizations an Internet-base database (facility management and energy costs/consumption of the buildings

Ventilation systems in existing residential building stock (Finland)

AGE OF BUILDING	NATURAL VENTILATION %	MECHANICAL EXHAUST %	MECHANICAL VENTILATION %
<1939	80	20	
1940-1959	80	20	
1960-1969	29	71	
1970-1979	6	91	3
>1980	0	100	

85 % connected into district heating

Examples on Renovation-Case (A multistorey house)

BACKGROUND

- During the next decade most of the apartment houses have to be renovated
- Moisture damages and poor indoor air quality are common problems in Finnish apartment storeys and detached houses
- The demand of energy efficiency has grown, building regulations concerning energy demands are changing
- The price of energy and water is rapidly growing
- Environmental impacts are important deed in decision making process

Examples on Renovation

SITUATION TODAY

- Development of energy audit method for apartments is on line
- Planning tools and guide books for energy saving has brought to the markets
- Public support for energy saving is probably growing in the future
- EU: Energy directive
- EU: Energy service directive

Examples on Renovation

Examples on renovation

RESULTS

- **Heating energy consumption decreased from 57 kWh/rm3 to 35 kWh/rm3**
- **Electricity consumption decreased from 18,7 kWh/rm3 to 15,7 kWh/rm3 (includes housing electricity)**
- **Water consumption decreased from 257 l/person, day to 114 l/person/day**
- **Costs (in 1996) 3000 FIM/floor-m2 (500 €/floor-m2), renovation degree was (renovation costs/ new construction costs) 45 %.**

Examples on renovation

HOW IT WAS DONE?

- By using new air ventilation technology (wall mounted system with heat recovery)
- By external insulation of outer walls and roof
- By new windows and balcony doors
- By new water and sanitary equipment system
- By measuring housing electricity and water consumption individually

Examples on renovation

CONCLUSIONS

- **Without renovation the expected life time of the building would be 10 years**
- **By LER (Low energy renovation) the life time of the building is now 50 years**
- **Payback time for LER is about 10 - 15 years**

Building envelopes

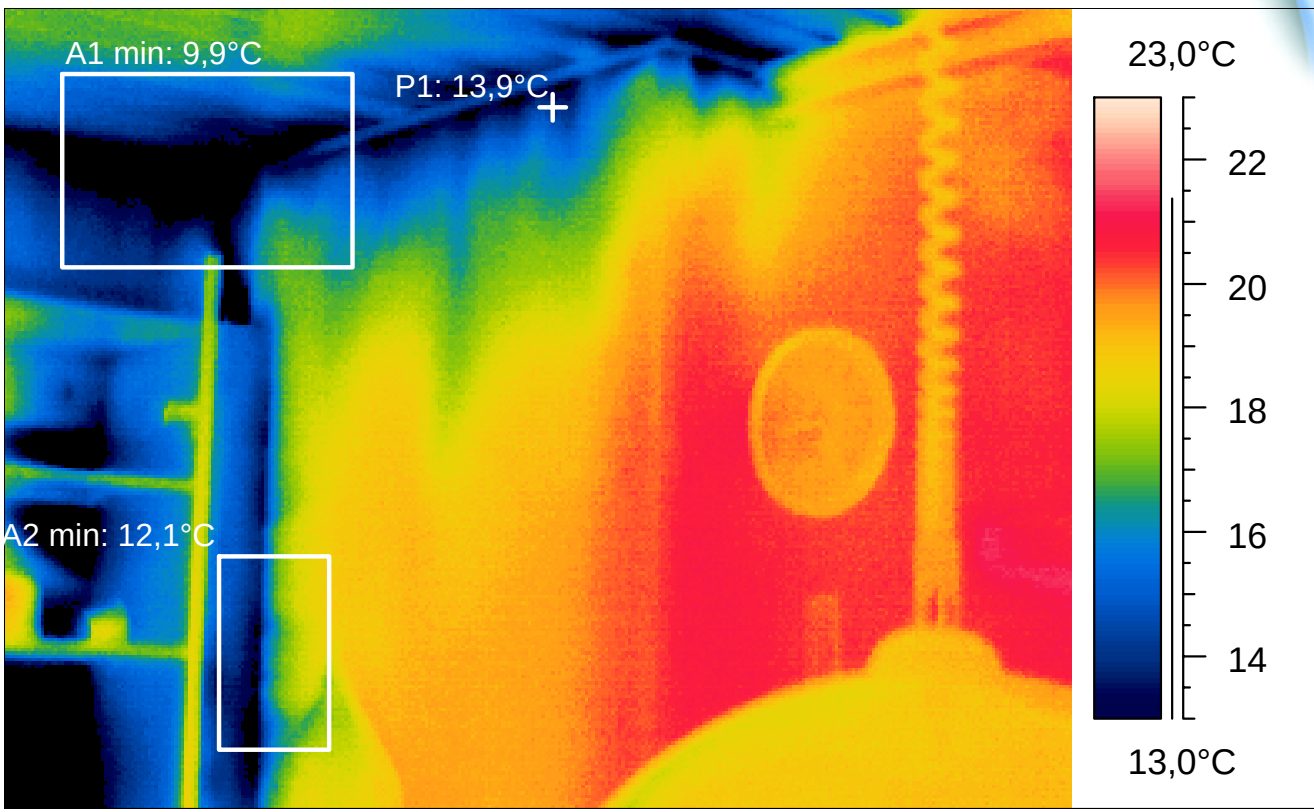
Thermal performance of the exterior wall and building parts

- **sum of various factors**

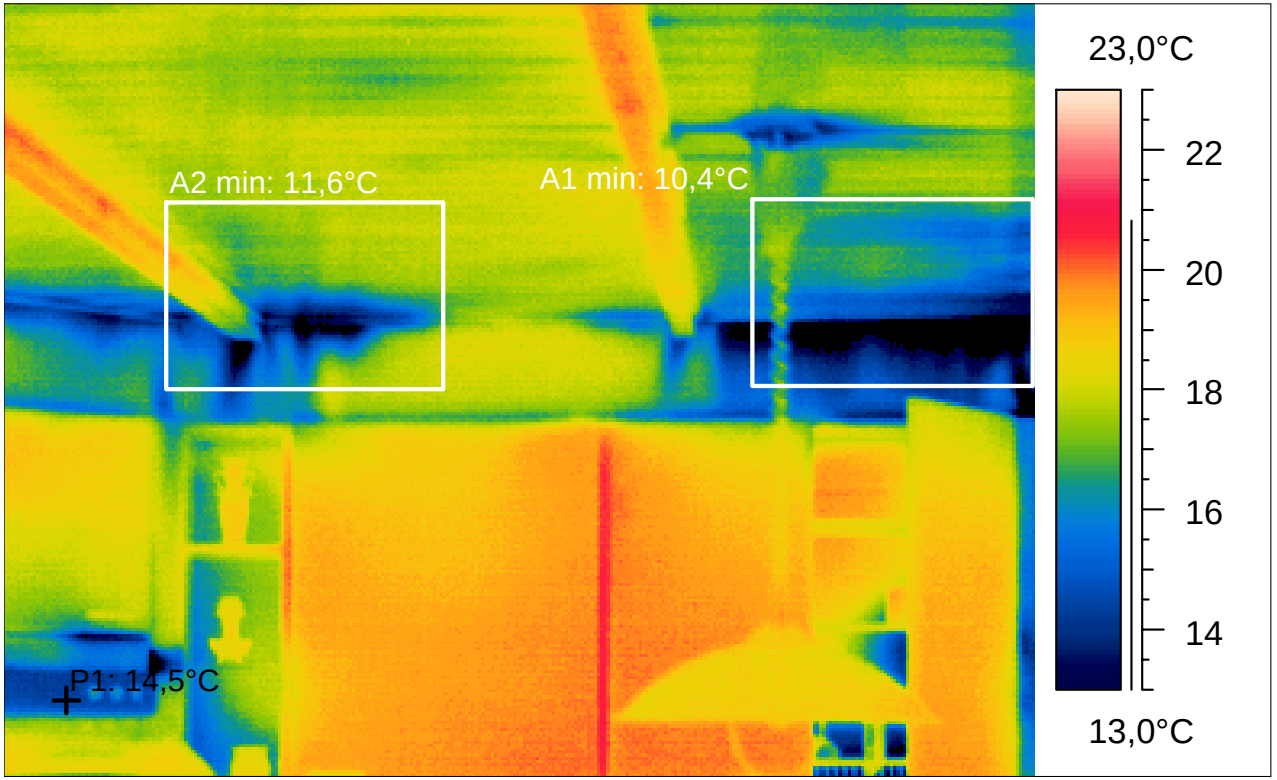
- **structures**
- **ventilation systems**
- **heating systems**
- **internal and external loads**
- **etc…**

Measurement and interpretation procedures needed (toolbox)

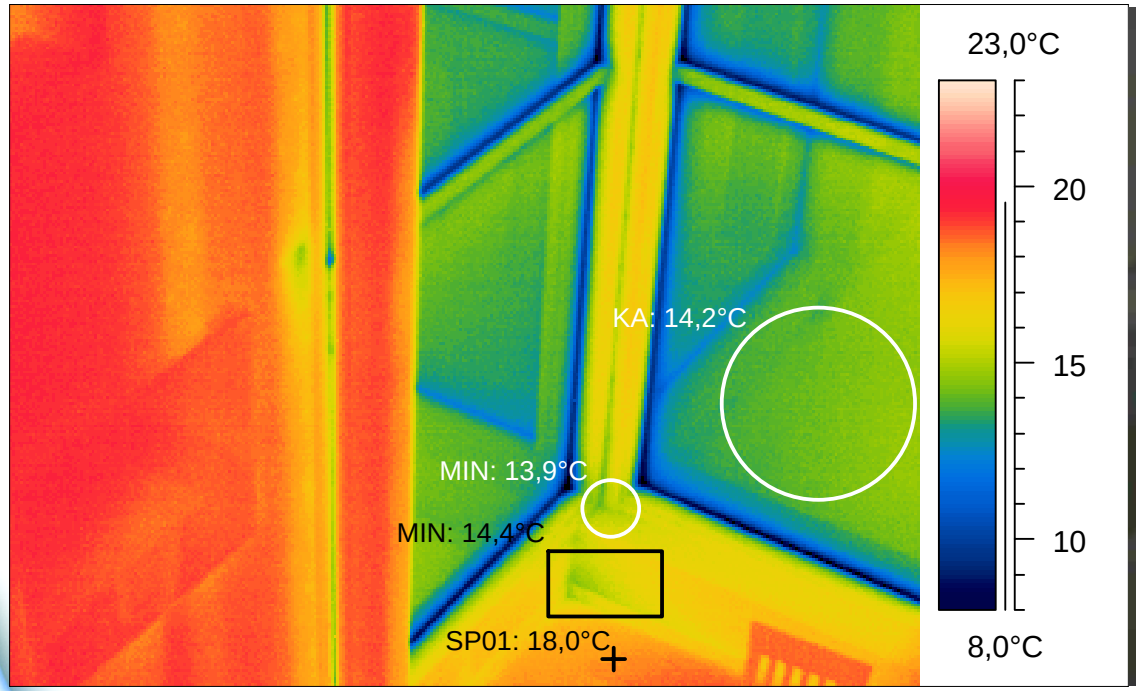
Thermography, air leaks (negative pressure drop)



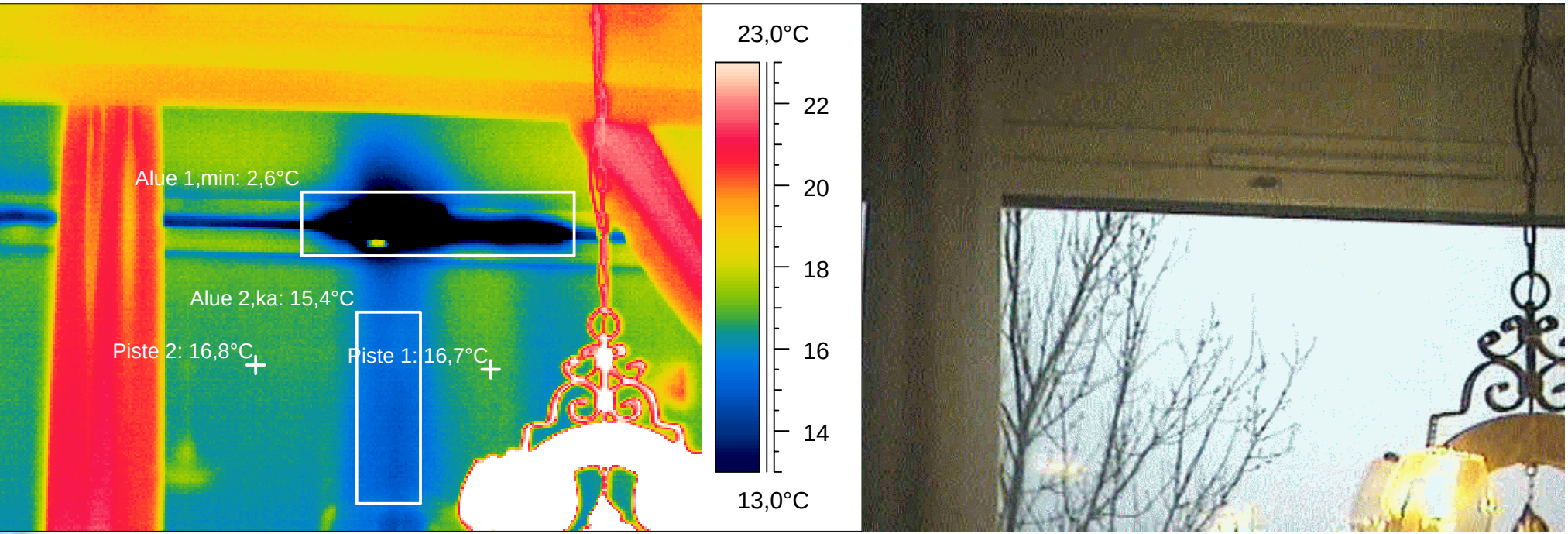
Thermography, air leaks (negative pressure drop)



Thermography, thermal comfort (floor heating + large high windows in the corner)



Thermography, air supply
Cold air cooling the window (floor heating)



Thermography, air supply
Cold air flowing downwards, loosening from the wall